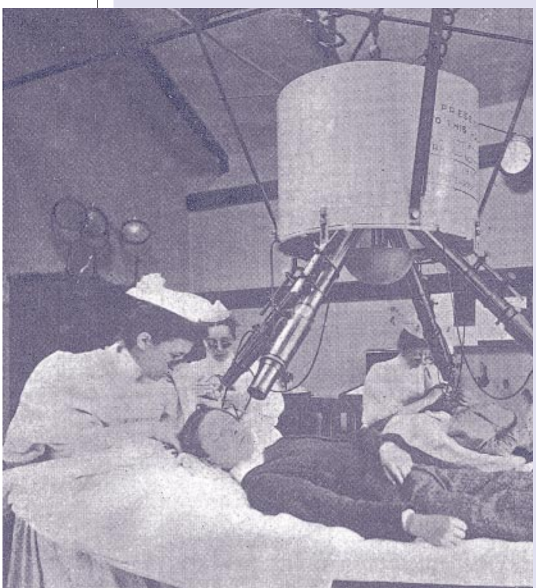
NATURE

100 YEARS AGO

The treatment of disease by light.
The drawbacks to the treatment are, first, the length of time which a severe case takes, and, secondly, the cost. Not only is there the cost of the electric light and the necessary maintenance, but every patient has to be attended by a nurse. At the London Hospital it has been found that it costs about 400*l*. or more a year to run one lamp, so that the light department there necessitates an expenditure of 1200*l*. a year. It is, therefore, gratifying to find that Mr. Alfred Harmsworth has come forward and endowed one lamp by a munificent gift of 10,000*l*.
From *Nature* 11 July 1901.



50 YEARS AGO

Normally, when an observer is making colour comparisons, he is in the erect position and with normal vision both eyes exhibit similar colour sensitivities. I have observed, however, that if the observer is in the prone position lying on one side, a gradual difference between the colour response of the two eyes develops. After a few minutes the lower eye becomes markedly red-sensitive compared with the upper eye. If now the observer lies on his back, the two eyes gradually return to equality of colour response. By turning on to the opposite side, the eye formerly red-sensitive will be uppermost and will then gradually develop blue-sensitivity compared with the lower eye.
From *Nature* 14 July 1951.

the brain's main inhibitory neurotransmitter.

After a century of research, we still do not know how or why blood flow increases during neuronal activation. It does not seem to reflect an increased need for either oxygen[9] or glucose[10]. But, thanks to the work of Logothetis *et al.*, cognitive neuroscience can move forward with greater confidence in the knowledge that changes in blood flow and oxygen levels do represent definable alterations in neuronal activity. ■

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High-energy physics

Disappearing dimensions

Joseph D. Lykken

Some theories of high-energy physics require extra spatial dimensions, beyond the three we know. A radical proposal turns this idea on its head, and suggests that dimensions may disappear at higher energies.

What is space? Where did the dimensions of our physical world come from? Philosophers since Aristotle have been flummoxed by these ancient questions. Now the particle physicists are having a go — turning philosophy into scientific hypotheses with testable consequences. Two groups of theorists[1,2], one based at Harvard University and the other at the Fermi National Accelerator Laboratory in Illinois, have suggested a concrete mechanism for how dimensions of space can come into being, and even disappear.

Aristotle got the first step right: to understand what a spatial dimension is, you need to think about motion. The convincing evidence that we live in three spatial dimensions is that we can move in three independent ways. Objects look three-dimensional because light (composed of particles called photons) moves in three dimensions, obeying three-dimensional laws of optics, and thus of perspective. Any question about dimensionality always boils down to a question about particles and their motion.

In a solid material like a crystal, atoms are held rigidly together, forming a regular lattice of point-like locations in three-dimensional space. Most of the electrons in that material are tied to one particular atom — they effectively live in a world of zero spatial dimensions, because their motion is completely constrained. But in some materials, such as metals, there are residual forces that allow some electrons to hop from one atom to another. Depending on the material, these 'hopping interactions' may allow motion only along a line, or only in a planar surface, or through the full three dimensions of the solid. So, for electrons in a solid, dimensionality effectively depends on forces.

The provocative models of Arkani-Hamed *et al.*[1] and Hill *et al.*[2] extend this analogy to elementary particles in a vacuum. Put the Universe under a powerful enough microscope, they say, and you will find that space itself is a lattice, an array of discrete points. Elementary particles, such as electrons, quarks or photons, fundamentally inhabit only a single point. To move, there must be a force — a hopping interaction — that destroys the particle at one point in space and creates a copy of it at a neighbouring point. No force, no motion; no motion, no dimension.

The Harvard and Fermilab theorists have created this microscopic picture of discrete space and hopping particles using simple models in which 'gauge' forces similar to three of the fundamental forces seen in nature — electromagnetic, weak and strong interactions — induce the hopping. Now here comes the tricky part. Gauge forces vary in strength according to the energy involved in the physical process. Electromagnetic forces, for example, get stronger at higher energies, whereas the strong nuclear force between quarks gets weaker at higher energies. In the models created by the two groups of theorists, the hopping interactions actually turn off at high energies, thereby reducing the number of spatial dimensions. Arkani-Hamed *et al.*[1], with postmodernist tongue-in-cheek, call this 'deconstructing dimensions'.

The punchline is that, in the high-energy environment of the early Universe, there may have been no spatial dimensions at all. Dimensionality itself may be a low-energy phenomenon, which emerged as the Universe cooled down.

This idea is a bit of a stretch even for the *cognoscenti* of string theory, the branch of high-energy physics that attempts a unified description of all fundamental interactions, including quantum gravity. In string theory, space itself — point, lattice or continuum — is supposed to emerge from a more fundamental substrate of wiggling strings. But in string theory there are more spatial dimensions visible at higher energies, not fewer. String theory, for its own consistency, requires ten spatial dimensions. The extra seven dimensions, it is assumed, are hard to see because they are 'curled up' to microscopic size. The number of spatial dimensions thus effectively increases with energy, because studying particle interactions at high energies is equivalent to probing matter at microscopic distance scales. Indeed, inspired by string theory, particle physicists are looking for evidence of extra spatial dimensions in experiments at high-energy particle colliders.

The new models of deconstructed dimensions do not include gravity, and so cannot yet vie with string theory as a complete description of the world at high energies. More than that, the existing models are really toys, not proper theories of anything. It could well turn out that there is less here than meets the eye. On the other hand, particle theorists have a strong bias that the laws of physics should become simpler at higher energies — and what could be simpler than a world of zero dimensions?

These ideas are extremely speculative, but in a generic way they should be testable. For example, the same experiments that are looking for extra dimensions using particle colliders might turn up evidence that quarks, electrons, gluons or photons are moving in fewer dimensions at the highest energies that can now be produced. The era of postmodern physics may be upon us. ■

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Palaeontology

Return to the planet of the apes

Henry Gee

Fossil evidence of human evolutionary history is fragmentary and open to various interpretations. Fossil evidence of chimpanzee evolution is absent altogether.

Discoveries of fossil hominids are like buses: nothing for a while, then three come along at once. Earlier this year, Leakey *et al.*[1] announced *Kenyanthropus platyops*, a 3.5-million-year-old creature with a disconcertingly modern-looking face, given its otherwise primitive cranium. At the same time, another team[2,3], also working in Kenya, described remains of a new species, *Orrorin tugenensis*, which at 6 million years old is possibly the earliest known hominid. These discoveries were discussed in accompanying News and Views articles[4,5].

In papers beginning on page 175 of this issue, Yohannes Haile-Selassie and colleagues now describe hominid specimens[6] and palaeoenvironments[7] from Ethiopia dated at between 5.2 and 5.8 million years old. The hominids are assigned to *Ardipithecus ramidus kadabba*, an archaic subspecies of *A. ramidus*, an early hominid previously discovered[8] in 4.4-million-year-old sediments in Ethiopia. The designation of *A. r. kadabba* as a subspecies will be controversial. But all concerned agree that both *Orrorin tugenensis* and *A. r. kadabba* are primitive, and they are thought to lie in the family tree close to the point at which the ancestries of extant chimpanzees and humans diverged. Their phylogenetic position is thus pivotal. Definitive resolutions of the status of these creatures could reveal much about the nature, lifestyle and behaviour of the most recent common ancestor of humans and chimpanzees, and the course of human evolution in general. Whether this potential can be fulfilled is another question entirely.

Their respective discoverers claim that both *A. r. kadabba* and *Orrorin* were bipedal. When *A. ramidus* was first described[8], bipedality was one of the few features that marked it as a hominid. But *A. r. kadabba* and *Orrorin* are more primitive still, raising the question of whether bipedality is a diagnostic hominid trait. In other words, bipedality, as an habitual form of locomotion, might have occurred in lineages of apes that are now extinct. This idea has found support, albeit controversially, in the claim that *Oreopithecus bambolii*, an ape that lived 7–9 million years ago on an isolated island that is now Tuscany, was bipedal to some extent — and yet this creature is thought to have become bipedal independently and was only distantly related to hominids[9].

The idea that bipedality was once more widespread than its current humans-only distribution has several implications. First, one would be forced to consider that the ancestors of chimpanzees as well as of hominids were bipedal, and that the distinctive knuckle-walking habit of living chimpanzees is a secondary acquisition. This challenges the controversial idea[10,11] that the most recent common ancestor of chimpanzees and humans was capable of knuckle-walking.

Second, it is possible that some of these fossils might not be hominids at all (see Box 1 for a guide to the terminology). After all, most researchers agree that the most recent common ancestor of humans and chimpanzees lived around 5–6 million years ago (but see ref. 12), so some of the fossils currently described as hominid might be more akin to chimpanzees, or may represent an entirely extinct offshoot of the ancestry of hominids and chimpanzees — a cousin of the latest common ancestor, if you like.

Moreover, it remains the case that although hominid fossils are famously rare,

Box 1 Hominid and hominin

A 'hominid' is a member of the family Hominidae, which classically includes all creatures, living and extinct, that are more closely related to *Homo sapiens* than to the extant chimpanzees (*Pan troglodytes* and *P. paniscus*), the closest living sister taxon to *Homo*. Senut *et al.*[2] and Haile-Selassie[6] use the term 'hominid' in this sense, and so, for consistency, I have done so in the main article here. This classical solution is, however, more problematic for the great apes — chimpanzees, gorillas (*Gorilla*) and orang-utans (*Pongo*) — which are lumped together in the family Pongidae. The problem is that some of these creatures (chimps and gorillas) are more closely related than others (orang-utans) to humans, in which case Pongidae is not a 'natural' group. One solution is to elevate chimps, gorillas and orang-utans each to their own families. Another is to extend the family Hominidae to include great apes as well as humans and their immediate, extinct relatives, classifying humans and chimps in a subfamily (Homininae) and demoting hominids (in the old sense) to the subcategory of tribe (the Hominini). This is why Leakey *et al.*[1], using this new terminology, describe as 'hominins' what others continue to refer to as 'hominids'. 'Hominin', therefore, is not necessarily a misprint or a gratuitous attempt to bemuse the unwary. **H.G.**